Charm Quark Production in Non-central Heavy Ion Collisions*

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Deep inelastic scattering experiments using nuclear targets showed that the quark and antiquark distribution functions are modified in the nuclear environment [1] and hence are different in heavy nuclei than in free protons. So far, all measurements and indirect determinations of nuclear parton distributions have been insensitive to the position of the parton within the nucleus. However, there is no reason to expect the parton momentum distributions to be constant within the nucleus. They should at least vary with the local nuclear density. If shadowing is due to gluon recombination, the position dependence could be quite strong [2]. One way to probe the position dependence of the shadowing is to measure $c\overline{c}$ production over a wide range of impact parameters, thus scanning gluon localization in the nucleus. Since the charm rate is large in central collisions [3], these studies are feasible at large impact parameters.

We assume that the nuclear number densities factorize into nuclear density distributions, $\rho_A(s)$, independent of x and Q^2, nucleon parton densities, f_i^p, independent of spatial position and A, and a shadowing function that parameterizes the modifications of the nucleon parton densities in the nucleus, dependent on x, Q^2, A and location *e.g.*,

$$F_i^A(x,Q^2,s) = \rho_A(s) S^i(A,x,Q^2,s) f_i^p(x,Q^2) \ .$$

If the parton densities in the nucleon and in the nucleus are the same, then $S^i(A,x,Q^2,\vec{r},z) \equiv 1$.

We introduce two parameterizations of nuclear shadowing and two models of the spatial dependence of the shadowing. The first parameterization is a fit to recent nuclear deep-inelastic scattering data which does not differentiate between q, $\overline{q}$, and g modifications and does not include Q^2 evolution. The second modifies the valence and sea quark and gluon distributions separately and also includes Q^2 evolution but is based on an older fit to the data.

The shadowing should depend on the spatial distribution of the partons within the nucleus so that $S^i(A,x,Q^2,\vec{r},z) \rightarrow 1$ as $s \rightarrow \infty$ since the shadowing mechanism should be less effective when the nuclear density is low. This spatial dependence should also be normalized so that $\frac{1}{A}\int d^2r dz \rho(s) S^i(A,x,Q^2,\vec{r},z) = S^i(A,x,Q^2)$ to recover the deep-inelastic scattering results which do not have any explicit impact parameter dependence. We assume both that the spatial dependence follows the nuclear matter density distribution and that the shadowing is proportional to the nuclear thickness.

We find that shadowing reduces the charm production cross section up to 35%. However, when the spatial dependence is included, the effect is decreased. By measuring the charmed quark production rates as a function of impact parameter, it is possible to study the effect of shadowing and to detect, for the first time, its localization within the nucleus, providing an indication of the gluon recombination distance scale.

The correlation between impact parameter and transverse energy has been used to fix b. We show that the impact parameter determination is reliable to within a 10% statistical uncertainty on an event-by-event basis for $b \approx 1.2R_A$. The systematic errors are expected to be comparable.

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